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Effect on strength of Involute spur gear tooth by considering Uncertainties in Geometry and Material propertiesby using Finite Element Methods-A Review

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Abstract: Gearing is the special division of Mechanical Engineering concerned with the transmission of power and motion between the rotating shafts. Gears not only transmit motion and enormous power satisfactorily, but can do so with very uniform motion. It is the best and the economical means of achieving this transmission. Gear teeth fail due to the static and the dynamic loads acting over it. This paper presents study of effect of various parameters on beam strength of involute spur gear tooth. The effect on strength of involute spur gear tooth is studied by considering uncertainties in geometric parameters like fillet radius, face width etc. Also the uncertainties in material properties which affect strength of involute spur gear tooth are studied.

Keywords: Fillet radius, face width

I. INTRODUCTION

A pair of teeth of gears in action is generally subjected to two types of cyclic stresses: bending stresses inducing bending fatigue and contact stress causing contact fatigue. Both these types of stresses may not attain their maximum values at the same point of contact. However, combined action of both of them is the reason of failure of gear tooth leading to fracture at the root of a tooth under bending fatigue and surface failure, like pitting or flaking due to contact fatigue.These types of failures can be minimized by careful analysis of the problem during the design stage and creating proper tooth surface profile with proper manufacturing methods. The finite element method is capable of providing this information, but the time needed to create such a model is large. In order to reduce the modeling time, a preprocessor method that creates the geometry needed for a finite element analysis may be used. Finite element method is very often used to analyze the stresses in an elastic body with complicated geometry, such as a gear.

To get the gear of more durability we can use improved material, hardening the gear surfaces with heat treatment and carburization, shot penning can be done to improve the surface finish, to change the pressure angle by using asymmetric teeth, introducing the stress relieving features of different shape, changing the addendum of the spur gear and altering the design of root fillet are the other methods.

Traditional deterministic design approaches compensate for uncertainties through the use of empirical safety factors, which do not provide sufficient information to achieve optimal use of available resources in terms of material, manufacturing and operational costs. To

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design a product that will perform a function reliably, the reliability must be considered as an important functional requirement all the way through the design process, from the customer's need to the final product. Addressing these issues comprehensively at an early design stage is necessary to produce competitive product that functions consistently during its intended service life. Indeed, consistent levels of safety and reliability can be achieved based on the probabilistic design methods.

Probabilistic design, such as reliability-based design and robust design, offers tools for making reliable decisions with the consideration of uncertainty associated with design variables or parameters and simulation models. It allows the designer to assess the reliability of the mechanical system. This is impossible with the factor of safety approach. One important task of a probabilistic design is uncertainty analysis, through which we under- stand how much the impact of the uncertainty associated with the system input is on the system output by identi -fying the probabilistic characteristics of system output. The uncertainty in a design performance is describedprobabilistically by its mean variance, the probability density function or the cumulative distribution function

By understanding the probability distributions of the design parameters, the designer can design for a specific reliability or quality level by producing designs that are robust to variations.[10]

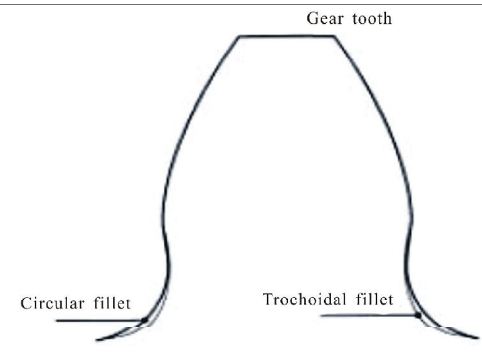

Fig.1 Gear tooth

II. REVIEW OF LITERATURE

Wilfred Lewis developed the basic model for bending stress in gear teeth in 1892. In his analysis, Lewis considered a gear tooth to be a loaded cantilever beam with a force applied to the tip of the gear. He made the assumptions like the load is applied to the tip of a gear tooth; only the tangential component of the force will be a factor (the radial component is neglected); the load is distributed uniformly across the entire face width of the gear; forces due to tooth sliding friction are negligible; and no stress concentration is present in the tooth fillet. [7] Christos A. Spitas and Vasilis A. Spitas [1] did his work on a new spur gear 200 design that works interchangeably with standard 200 system and achieves increased tooth bending strength and hence the load carrying capacity. In this design, circular fillet replaces the normal trochoidal fillet, yielding large cross sectional at the tooth root and lower stress

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con-centration. V. Spitas, Th. Costopoulos and C. Spitas [2] did his work on spur gear teeth with circular instead of the standard trochoidal root fillet is introduced and investigated numerically using Finite Element Analysis. M. Savage and Rubadeux [3] has propose a bending strength model for internal spur gear teeth, this mod-el assist design efforts for unequal addendum gears and gears of mixed materials. M Koilraj, Dr. G Muthuveerappan and Dr. J. Pattabiraman [4] on the basis of their work give the conclusion that, the stress correction factor and the form factor in-creases with the increase in positive profile correction.The modified pitch cone method is first presented and verified in the gear research center of Dong Feng vehicle-bridge Co. Ltd. [6] 3D static and dynamic contract/impact analysis of gear drives were developed by Rufang Li. The tooth load allocation and result are derived under the static load. The analysis of the stress distribution of gear system under dynamic loading conditions and simulates the stress of gears under conditions of initial speed and a sudden load being applied. [6]

Kawalec et al developeda comparative analysis between ISO and AGMA tooth root strengthevaluation methods and verification by FEM. Li studied contact strength and bending strength of spur gears with machining errors, assembly errors and tooth modifications by 3-D FEM models. Pedersen proposed asymmetric profiles to improve the bending stress in spur gears. But neither of them considers analytical, non-uniform models of load distribution. [9]

Zeping Wei [6] used three dimensional finite element methods to conduct surface contact stress and root bending stress calculations of a pair of spur gears with machining errors, assembly errors and tooth modifications. Deng used tooth contract analysis, loaded tooth contact analysis and finite element method to analyze the meshing behavior, tooth surface contract stress, maximum tensile, bending stress and maximum compressive bending stress.

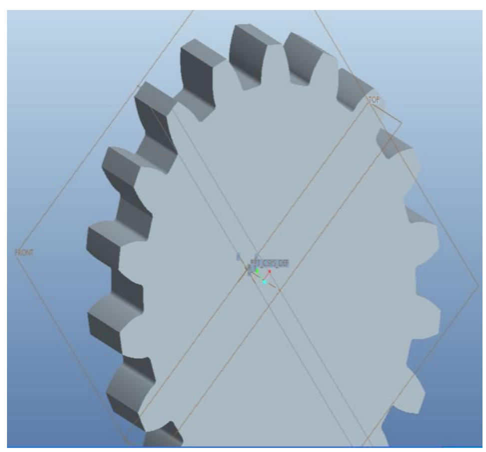

Fig.2Gear Model

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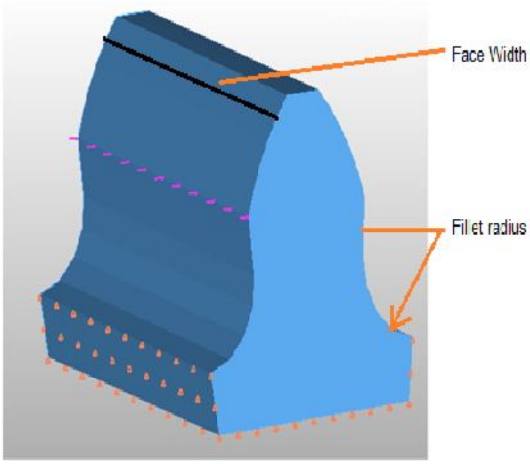

Fig.3 FE Representation of the Model

IV CONCLUSION

The effect on the strength of spur involute gear by changing the radius of the circular fillet was investigated. Gears of different parameters but having same module and pressure angle was modeled and the distortion produced in the curvature due to the loading at the highest point of single tooth contact was analyzed by using Finite Element Analysis. It is also concluded that, the value of the deflection in the curvature of the gear is more in the gear of more number of teeth.

The effect of gear ratio, face width, normal module on optimum beam strength is carried out. If face width, speed and normal module except gear ratio are kept constant and gear ratio is increased, the corresponding beam strength remained constant. The gear ratios, speed, normal module except face width are kept constant and face width is increased, the corresponding beam strength found to increase. The face width, gear ratio and speed except normal module are kept constant and normal module is increased, the corresponding beam strength found to increase.

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